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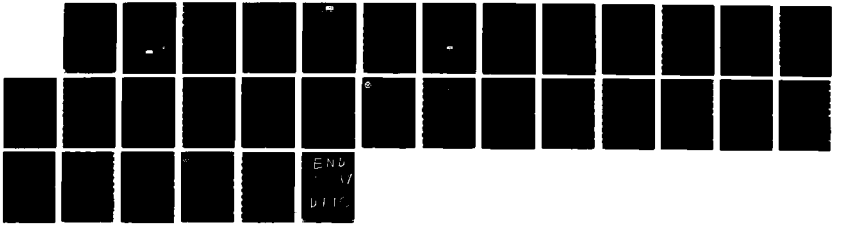

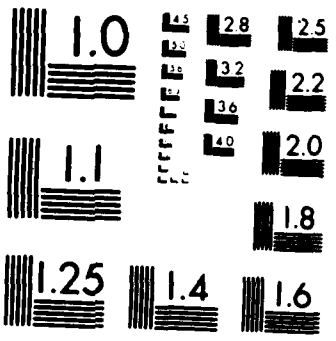

CRM 87-40 / March 1987

RESEARCH MEMORANDUM

MANAGING SUSTAINING ENGINEERING IN WEAPON SYSTEMS: PHASE I

Lewis R. Cabe
John E. Keller
Don W. Rehorst
William B. Tomlinson

A Division of CNA Hudson Institute

CENTER FOR NAVAL ANALYSES

4401 Ford Avenue • Post Office Box 16268 • Alexandria, Virginia 22302-0268

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This research memorandum explains the origin of the VCNO's tasking of CNA to study sustaining engineering. It describes the analytic and procedural approach to the problem as originally conceived and reports some of the early substantive findings. The most important of these was that the Navy does not know, nor can it currently find out in a comprehensive and systematic way, the specific services it receives as a result of its annual expenditure of approximately $1 billion on sustaining engineering for aircraft and missiles. When these preliminary results were briefed to the VCNO, the original tasking was revised and expanded. The general contents of subsequent documents in this series are also outlined.

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MEMORANDUM FOR THE VICE CHIEF OF NAVAL OPERATIONS

Subj: Center for Naval Analyses Research Memorandum 87-40

Encl: (1) CNA Research Memorandum 87-40, "Managing Sustaining Engineering in Weapon Systems: Phase I," by John E. Keller et al., Mar 1987

1. Enclosure (1) is forwarded as a matter of possible interest.

2. This research memorandum explains the origin of the VCNO's tasking of CNA to study sustaining engineering. It describes the analytic and procedural approach to the problem as originally conceived and reports some of the early substantive findings. The most important of these was that the Navy does not know, nor can it currently find out in a comprehensive and systematic way, the specific services it receives as a result of its annual expenditure of approximately $1 billion on sustaining engineering for aircraft and missiles. When these preliminary results were briefed to the VCNO, the original tasking was revised and expanded. The general contents of subsequent documents in this series are also outlined.

Robert J. Ravera
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CRM 87-40 / March 1987

MANAGING SUSTAINING ENGINEERING IN WEAPON SYSTEMS: PHASE I

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ABSTRACT

This research memorandum explains the origin of the VCNO's tasking of CNA to study sustaining engineering. It describes the analytic and procedural approach to the problem as originally conceived and reports some of the early substantive findings. The most important of these was that the Navy does not know, nor can it currently find out in a comprehensive and systematic way, the specific services it receives as a result of its annual expenditure of approximately $1 billion on sustaining engineering for aircraft and missiles. When these preliminary results were briefed to the VCNO, the original tasking was revised and expanded. The general contents of subsequent documents in this series are also outlined.

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INTRODUCTION

It is generally accepted that there are three basic phases in weapon system engineering: original design engineering, sustaining engineering, and systems engineering. While different nomenclature is sometimes used, and "systems engineering" can have other meanings in other contexts, most groups involved in weapon system engineering agree with the following definitions developed by the Center for Naval Analyses (CNA):

- Original Design Engineering. All engineering effort, including that involved in development, test, and evaluation, leading up to a final approved weapon system design; that is, all engineering effort occurring prior to completion of the Physical Configuration Audit, when the design is frozen for the first full-scale production article.

- Sustaining Engineering. Engineering effort involved in setting up and improving production processes, ensuring systems integration, advising on and correcting deficiencies discovered during manufacturing and service use, and assisting in other phases of manufacturing such as quality assurance and configuration control; also the engineering required to ensure that current production articles meet explicit or implicit specifications.

- Systems Engineering. Engineering effort applied to existing weapon systems to enhance performance, reliability, or maintainability significantly beyond current specifications; or, engineering involved in the design of improved models of a current weapon system.

For reasons to be explained subsequently, in June 1985 the then Vice Chief of Naval Operations (VCNO), Admiral Ronald Hays, tasked CNA to study sustaining engineering (SE). This research memorandum is the first of a series reporting the results of the study. It is intended to serve several purposes:

- Explain the origin of the VCNO's tasking and the perceived nature of the problem.

- Outline the methodology, the plan of action as originally conceived, and the changes made as the study progressed.

- Report certain of the findings presented to the VCNO in a briefing in April 1986.

- Summarize the new and expanded VCNO tasking resulting from the April briefing.

- Describe actions taken by the Naval Air Systems Command (NAVAIR) as a result of the April briefing.

- Preview the research memorandums that will follow this one.

ORIGIN OF THE VCNO's TASKING

In May 1985, CNA presented a briefing to Admiral Hays, then the VCNO, and Mr. Paisley, then the Assistant Secretary of the Navy (Research, Engineering, and Systems), on ways to improve budgeting, accounting, and controls for what was called Contractor Support Services (CSS) at that time and is now referred to as Contracted Advisory and Assistance Services (CAAS).[1] One of the major reforms proposed was to adopt a new set of sound and consistent definitions for CAAS as a whole and for each of its major categories. A principal criterion in developing the overall definition of CAAS was to emphasize that it involves temporary or intermittent "consulting services" of an "advisory and assistance" nature. Use of these criteria suggested that engineering and technical services integral to the normal development and production processes (i.e., the three basic phases of weapon system engineering defined above) were not CAAS and the formal definitions in the new CAAS directives clearly reflected these exclusions.

While agreeing with these definitional distinctions, Admiral Hays and ASN Paisley shared certain concerns about SE. First, it was the least understood aspect of weapon system engineering. Second, the new definitions put it beyond the purview of the proposed new controls being applied to CAAS. Third, it provided a potential "hiding place" for one of the other major nonengineering categories of CAAS--Studies, Analyses, and Evaluations. And, fourth, evidence developed during the CAAS study indicated that under certain contractual arrangements, the Navy has little visibility into or control over what weapon system contractors do with the man-hours and funds proposed for SE. After the briefing, the VCNO charged CNA to address these issues. This verbal charge was formalized in a VCNO tasking memorandum, which is reproduced in appendix A.

THE PROBLEM AS ORIGINALLY CONCEIVED

As originally conceived, analyzing the problem appeared to require undertaking the following tasks:

- Define SE and the related forms of weapon system engineering in a comprehensive and integrated way.

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1. CNA's recommended changes were subsequently incorporated in a Department of Defense (DOD) directive and companion SECNAVINST. Both of these directives use the new term "Contracted Advisory and Assistance Services" (CAAS) in lieu of the older "Contractor Support Services" (CSS).

- Define SE, in particular, in terms of the specific tasks or functions performed.
- Estimate on a consistent basis the dollars invested in SE and aggregate them in various ways, particularly by weapon system and system command.
- Determine the products or services obtained from SE expenditures.
- Categorize the products or services obtained on the basis of their value to the Navy.
- Suggest alternative methods for increasing the Navy's visibility into and control over SE to ensure it gets its money's worth.
- Determine if a more uniform contractor cost reporting system would be feasible and cost effective.

As this first phase of the study progressed, however, it became necessary to modify the original plan. The changes, and the reasons therefor, are described in subsequent sections of this report.

METHODOLOGY

A fortunate early development in the study was the interest and support expressed by the F-14 program office in NAVAIR (PMA-241). Discussions with members of that office confirmed and expanded the study team's original ideas about what constitutes weapon system engineering in general and SE in particular. PMA-241 staff members also acquainted the study team with a number of current issues in estimating, managing, and accounting for SE hours and dollars. They also expressed general agreement with what the study team thought were important "drivers" of SE. In addition, they agreed with the hypothesis that, without perturbations in the production process or a sharply increased requirement to support operational aircraft, the need for SE in a particular program should decline over time.

Similar discussions were conducted with program managers, business managers, contracting officers, and engineers in NAVAIR program offices. As a result, the study team was able to develop definitions of the three basic phases of weapon system engineering (outlined in the Introduction), the specific tasks constituting SE (shown in table 1), a formal questionnaire (appendix B), and a standard data format (appendix C).

At this point, four significant decisions were made. First, the basic form of the study would be a comparative analysis among weapon systems in three broad groups--aircraft and missiles, shipboard weapons and related systems, and surface ships and submarines. Second, because

TABLE 1

TASKS OF SUSTAINING ENGINEERING

1. Participating in laying out and modifying production processes

2. Resolving problems of systems integration

3. Correcting production problems identified by:
   - Production supervisors and quality assurance personnel
   - Contractor and Service flight tests (Flight CRABS)

4. Undertaking engineering investigations resulting from fleet-identified problems:
   - Accidents and incidents
   - Unsatisfactory reports by squadron pilots (design-related problems rather than simple malfunctions)

5. Preparing all engineering change proposals (ECPs)

6. Preparing detailed drawings and specifications for approved correction-of-defects (COD) engineering change proposals (ECPs)

7. Supervising implementation of COD ECP work

8. Conducting engineering investigations to enhance producibility

9. Initiating and evaluating value engineering proposals

10. Conducting engineering efforts to ensure that reliability and maintainability meet contract specification or desired levels

11. Providing engineering input to configuration control

12. Updating drawings, rewriting specifications, and providing engineering input to technical publications and manuals

13. Maintaining contractual engineering documentation

14. Overseeing supplier operations and products

15. Maintaining liaison with Service acquisition managers and their field activities

16. Managing in-house sustaining engineering efforts

of the study team members' experience, and because of the continuing support of PMA-241, the study team chose the aircraft and missiles group as the first to be analyzed. Third, because the data resources of the relevant Navy program offices were limited, and because a first-hand appreciation of the environment in which SE work is done was important, on-site interviews and facility tours of contractors were added to the schedule. And fourth, to enrich the data base and get different views about managing SE, Air Force aircraft were added to the systems to be studied.

The sites visited and weapon systems studied in this first phase of the analysis were: the Air Force's F-16 System Program Office (SPO) at Wright-Patterson AFB, Ohio; Grumman Aerospace Corp. at Bethpage, New York (F-14); McDonnell Douglas Aircraft Corp. at St. Louis, Missouri (F-15 and F-18); General Dynamics Corp. at Fort Worth, Texas (F-16); Texas Instruments at Lewisville, Texas (HARM missile); Lockheed Missile and Space Co. at Sunnyvale, California (Trident C-4 missile); and Boeing Aerospace Corp. at Seattle, Washington (727 and 737 commercial aircraft and the E-3/AWACS military aircraft).

PRELIMINARY RESULTS BRIEFED TO THE VCNO

On 29 April 1986 the results of the study up to that point were briefed to Admiral James Busey, the current VCNO (and former Commander, NAVAIR), Mr. Paisley (ASN-RE&S), and a large group of concerned senior Navy officers. The briefing provided only preliminary results, not just because of the small number of aircraft and missiles studied, but also because of certain limitations affecting the study to that point. These limitations are described in the following discussion of the preliminary findings.

Despite the limitations, a number of the preliminary results could be stated with some confidence:

- There was near-unanimous agreement about the definitions of the three basic phases of weapon system engineering and the individual tasks constituting SE. Not all of the contractors perform all of these tasks (table 1), but they agreed that conceptually the tasks are part of the overall SE function.

- The Navy spends roughly $1 billion annually on SE for aircraft and missiles. These dollars buy approximately 17 million SE man-hours. For reasons noted below, however, it is impossible to say on any consistent or comprehensive basis what outputs (products or services) these inputs buy.

- Methods for estimating, budgeting, recording, and controlling SE hours and dollars varied widely among contractors.

Even in the best case, only a partial accounting for the products and services could be made--at least in terms of the tasks detailed in CNA's definition of SE. In the worst case, no accounting was possible below the aggregate of all SE hours and dollars. There were also wide differences in how, and how well, the estimating and budgeting functions were performed.

- Similarly, there were wide differences among program offices within NAVAIR in their ability to identify, account for, and analyze even the aggregate SE hour and cost data. The HARM program was a notable exception; it has an excellent tracking and analysis system.

- Obtaining complete and consistent data, even on aggregate SE hours and costs, was a major problem for the study team. While contractors, Plant Representative Offices (PROs), Navy program offices, and Air Force System Program Offices (SPOs) agreed with CNA's definitions and found the standard quantitative data sheet (appendix C) a sensible way to array the data, it required varying degrees of manipulation of the contractors' internal accounting systems to put the relevant data in CNA's format. In fact, because the data set was still incomplete and contained unresolved inconsistencies at the time of the April briefing, very little quantitative analysis could be performed. However, because even the limited amount done was provocative, the VCNO asked the study team to resolve the data deficiencies and complete the analyses. Over the course of the next several months this was done. The results will be reported in later research memorandums in this series.

- A uniform system for reporting contractor cost and man-hour data is specified in DOD Instruction 7000.11. The instruction is, however, widely ignored, even when the reports it calls for are submitted. The problem seems to be that it was designed for certain kinds of macro cost modeling rather than for management purposes or the kinds of analyses CNA undertakes. (Some contractors use parts of the Contractor Cost Data Reporting (CCDR) system and its associated Work Breakdown Structure (WBS) for their own internal tracking and controlling systems.) The CCDR/WBS system is, however, virtually useless for managing SE because SE hours are scattered throughout the WBS. Further, the time lag in CCDR reporting precludes its use for real-time management or analysis. Even as a basis for long-term analyses, it has shortcomings because of anomalies in the WBS. For example, the WBS is a mixture of physical parts of the aircraft and groups of functions

(e.g., systems engineering), some of which contain dissimilar components. A reform is needed and appears feasible, but it would require a large-scale, multiservice effort.

- Methods of accounting for and controlling Class I Engineering Change Proposals (i.e., those that result in some change to form, fit, function, or cost of a system) also varied much more than would have been expected for such a long established and ostensibly closely regulated process.

- It gradually became evident during this first phase of the study that there are substantial differences in how supervisory groups (contractors' program management offices and engineering departments, PROs, Defense Contract Audit Agency offices, Navy program offices, and Air Force SPOs) are organized and staffed. These differences exist not only among contractors and between the Navy and the Air Force, but even within the Navy. For example, the Strategic Systems Project Office (SSPO) and the Joint Cruise Missile Project Office (JCMPO) in the Navy are far more heavily staffed and more self-sufficiently organized than any other Navy program office--and, in fact, they outdo the largest Air Force SPOs in these respects. Other less dramatic, but nevertheless significant, differences exist within NAVAIR.

  The study team's observations on this point are not an endorsement of "more is better" when it comes to management staffing. Too many offices at the same level doing closely related functions, or too many levels of management, are common organizational weaknesses. But in the present case, larger commitments of oversight resources at the program office and SPO levels do seem to have a positive effect, not only on SE management but on overall management and product quality as well. The unresolved issues are these: At what point are the marginal benefits of investments in oversight personnel and systems no longer worth the marginal costs? And even before that point is reached, what are the opportunity costs of the management manpower committed to SE?

- As the first phase of the study progressed, the inability of the study team (or the Navy, or even the contractors) to identify what services resulted from the SE man-hours expended became increasingly evident. The research focus shifted, therefore, from its original emphasis on measuring and comparing outputs to concern about SE's contribution to product quality--that is, to measures of effectiveness related to aircraft safety, reliability, and

maintainability which are believed to be influenced by SE. This shift occurred too late to permit systematic gathering of data in time for the April briefing for measures such as not-mission-capable rates, zero-defect aircraft, unscheduled maintenance hours per flight hour, mean time between failures, and aircraft mishap rates caused by materiel and engineering shortcomings. What data did become available suggested that well controlled and moderate use of SE hours and dollars (on a comparative basis) did not degrade product quality. Clearly, however, this new focus on SE usage in relation to weapon system quality warranted further conceptual development and more complete and systematic data gathering.

- Many alternatives exist for improving management of SE. Identifying preferred mixes is beyond the scope of this paper. Nevertheless, it appears that implementing some of these alternatives--including more regular purchase of full cost and schedule information, greater use of incentive features in contracts, and better methods for estimating SE needs--would strengthen the negotiating position of Navy program managers. Given the magnitude of the expenditures involved (approximately $1 billion annually), even modest improvements could significantly reduce the cost of Navy aircraft and missiles. (NAVAIR has already implemented some of the study team's recommendations.)

THE VCNO's REVISED AND EXPANDED TASKING

As a result of the CNA briefing of 29 April 1986 to Admiral Busey and ASN Paisley, the VCNO revised and expanded CNA's tasking. (See appendix E for the new tasking memorandum.) The changes fall under two main headings: scope and emphasis.

Scope

The VCNO directed CNA to:

- Solve the data problems and complete the work on the original sample of aircraft and missiles
- Add the A-6E, E-2C, AV-8B, and P-3 aircraft to the sample, as well as the Tomahawk, Harpoon, Phoenix, Sparrow, and Sidewinder missiles
- Begin work on surface ships, submarines, and shipboard weapon systems, including torpedoes and electronic subsystems.

Emphases

The VCNO also directed CNA to emphasize the following topics:

- Relationships between SE usage, its management, and measures of effectiveness related to product quality
- Techniques for estimating the need for SE
- Management of Engineering Change Proposals
- Organizational arrangements to enhance program managers' ability to negotiate and control SE.

NAVAIR's ACTIONS

Immediately following CNA's briefing to the VCNO, The Commander of NAVAIR, Vice Admiral Wilkinson, formed an ad hoc SE study group to critique CNA's preliminary results and make recommendations to the Command Advisory Board. This group completed its work within three months.

While the members of the study group registered a few dissents from the CNA proposals, in general they agreed with CNA's findings and suggestions. More importantly, the Board recommended, and Vice Admiral Wilkinson approved, a plan of action to accomplish the following:

- Formally define SE and the tasks under it that may be properly charged to production contracts.
- Develop and promulgate a uniform policy on handling Class I Engineering Change Proposals.
- Adopt, as a command-wide model, the procedures used by the HARM missile procurement contracting officer (PCO) for managing SE. (CNA had identified this PCO as being the most informed and effective one encountered in the interviewing and data gathering process.)
- Bring the class desk officers more fully into the contract negotiating process.
- Create a command-wide historical data base on SE.

ADDITIONAL RESEARCH MEMORANDUMS

The second research memorandum in this series will cover the results of site visits involving the F-14, F-15, F-16, F-18, and AWACS aircraft and HARM and Trident C-4 missiles. Subsequent ones will cover site visits involving the additional aircraft and missiles specified by the VCNO. Still others will summarize the analyses pertaining to aircraft and review the supporting data.

APPENDIX A

VCNO MEMORANDUM, 11 JUNE 1985

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, DC 20350-2000

IN REPLY REFER TO
Ser 09/5U301100
11 June 1985

MEMORANDUM FOR THE PRESIDENT, CENTER FOR NAVAL ANALYSES

Subj: ANALYSIS OF SUSTAINING ENGINEERING

1. Commodore J. D. Taylor presented a briefing recently on our progress in improving the management and reporting of Contracted Advisory and Assistance Services (CAAS). My assessment is that a great deal has been accomplished, both conceptually and practically, in bringing this long-standing problem under control. I appreciate the active and efficient role CNA has played in contributing to these improvements.

2. In responding to an earlier concern of the Assistant Secretary of the Navy (RE&S), Commodore Taylor verified that an important element of the engineering effort that goes into weapon system production and deployment--sustaining engineering--is, under some contractual arrangements, apparently immune to the controls in the new CAAS management system. A case can be made that several hundred million dollars' worth of engineering effort annually is available to contractors to use as they choose with little or no visibility or control by senior Navy management.

3. We must pursue immediately a range of actions to gain better control of sustaining engineering costs. One of these actions must be a concentrated, systematic study to determine the extent and severity of the problem and to propose and evaluate a broad range of alternative solutions. Your involvement in the "parent" CAAS/CSS problem over the past year ideally qualifies CNA to undertake this study. The study should address, but need not be limited to, the following questions:

a. How much are we spending annually for sustaining engineering?

b. What are we buying?

c. What do we need?

d. What can we do to improve our management and control of sustaining engineering costs?

4. Commodore Taylor discovered also that a major hindrance to comparative analysis in this area is the wide difference in the systems used by contractors for recording contract cost data. In the course of the study, therefore, I would like you to investigate the feasibility of a more uniform contract cost reporting system.

Subj: ANALYSIS OF SUSTAINING ENGINEERING

5. Please provide an analysis plan to accomplish these tasks at your earliest convenience. I would appreciate your preliminary results in September 1985 with a final report by 1 December 1985. My point of contact for this project is Commodore J. D. Taylor, OP-921, 695-3263.

Ronald J. Hays

RONALD J. HAYS
ADMIRAL, U. S. NAVY
VICE CHIEF OF NAVAL OPERATIONS

Copy to:
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CNO (OP-090)
DIRONAS

APPENDIX B

QUESTIONNAIRE ON MANAGEMENT OF SUSTAINING ENGINEERING

APPENDIX B

QUESTIONNAIRE ON MANAGEMENT OF SUSTAINING ENGINEERING

(This questionnaire was sent to contractors in advance of the study team's visit to assist them in preparing for the visit and to provide a structure for the on-site discussions. Most contractors had formal responses ready at the time of the visit.)

1. Given the attached definitions of "original design engineering," "sustaining engineering," and "systems engineering," are there any significant overlaps? Are there any other major categories of engineering besides these three?

2. In terms of the kinds of contracts involved (e.g., FFP, FPI, CPFF), what has been the contractual history of this system in the production phase? Is sustaining engineering (SE) included in the current production contract? Is it a contract line item? Is it in a separate contract? If it is in a separate contract, what type of contract is it? Can you break SE man-hours out of the relevant contracts by all or some of the components shown in the attachment? If not, can they be broken out using some other method? In either case, can you supply these data on an actual basis for all of the regular production years, plus estimates for FY 1985 and FY 1986? (See attached standard data format.) [The standard data format is presented in appendix C of this research memorandum.]

3. Can you show how sustaining engineering man-hours are a function of any of the following SE "workload indicators?"

   Production rates
   Class I Engineering Change Proposals (ECPs)
   Class II engineering changes
   Pre-acceptance tests
   Material review actions
   Vendor certification and recertification
   Number of deployed systems
   Engineering investigations
   Contract data items
   Amount of test equipment
   Field service reports
   Message traffic from fleet
   Other correspondence

   Do you use these or similar indicators as the basis for calculating the total number of SE man-hours included in your annual contract proposals? Or, do you budget SE on a level-of-effort basis geared to an anticipated peak demand? Or, do you negotiate and authorize specific SE tasks either sequentially or as an annual package? Or do you estimate SE man-hour requirements based on a "learning curve"

derived from earlier production history of this or a similar system? If you use none of these methods, how do you determine SE needs?

4. It seems reasonable to assume that the number of sustaining engineering man-hours in support of production would decrease over time (absent design changes), or as production quantities are reduced. Is this correct? If not, what are the factors that would counteract these assumed trends?

5. It also seems reasonable to assume that problems associated with in-service weapon systems, and hence, the sustaining engineering effort needed to resolve them, would decrease over time. Is this correct? If not, what countervailing factors are at work?

6. Are the following included as separate line items in an overall procurement contract, or are they covered by separate contracts? Which of these categories include sustaining engineering?

    A. Production of the basic weapon system

    B. Initial spares

    C. Special support equipment

    D. Trainers

    E. Technical publications

    F. ILS

7. What is the extent of competition in subcontracting/vendor procurement?

8. Is there any foreign subcontracting or co-production? How extensive is it?

9. For recent FYs, by fiscal year, how many Class I Correction of Deficiency (COD) ECPs were prepared; of those prepared, how many were implemented? For all ECPs prepared in each fiscal year, how many man-hours were required and of these totals how many were considered SE? For those ECPs implemented in each fiscal year, how many man-hours were required and of those how many were considered SE?

10. How are engineering man-hours for correction of deficiency problems charged? By what system are design correction costs assigned to a particular fiscal year contract(s)? How are corrections while under warranty paid for (i.e., implicitly or explicitly in the production contracts)?

11. Do annual production contracts include costs for correcting nonwarranty design deficiencies that affect all weapons systems in service? If so, wouldn't this distort the apparent production cost and price of the weapons systems in that year's contract? Would it be better to have a separate contract or a separate line item in the production contract for each of those costs not associated with production of the new weapons systems?

12. Where and how are the costs of answering "what if" questions charged?

13. Does your sustaining engineering staff produce formal studies? If so, could you furnish a list of these for the past few years? How is the time charged to produce these studies? Who determines what studies will be produced?

14. How much, if any, "systems engineering" work is done under production contracts (i.e., engineering effort to improve the performance of the weapon system beyond the current design)? Where would these hours be charged?

15. Do you report hours and dollars in accordance with DOD Instruction 7000.11 (i.e., CCDR/WBS data)?

16. In addition to, or in lieu of, CCDR data do you gather and report Cost and Schedule Control System (C/SCS) information? If so, what is the annual cost to the government? If it is used only for internal company purposes, what would it cost the government to obtain it?

APPENDIX C

SUSTAINING ENGINEERING STANDARD DATA FORMAT

SUSTAINING ENGINEERING STANDARD DATA FORMAT

(All numbers in thousands)

	FY[1] (Include each intervening FY)	FY 85 (est.)	FY 86 (est.)
Manhours by Contract Year			
Total manhours			
- Production ("Touch Labor")			
- Sustaining engineering			
-- In support of production			
-- In support of deployed systems			
- All other manhours[2]			
Production by Contract Year			
Number of vehicles/platforms/systems contracted for[3]			
Average monthly production rate[4]			
Price by Contract Year (then-year dollars)			
Total production contract[5]			
A. Prime contractor (in-house)			
1. Vehicle/platform/system (including SE)			
(a) (Included SE)			
2. Other hardware[6] (including SE)			
(a) (Included SE)			
B. Major subcontractors[7]			
C. All other subcontracting[8]			
D. All "burdening" functions[9]			

[1] First year of regular production
[2] Configuration control, QA, program management, etc.
[3] Show type, model, series, or equivalent
[4] Show annual rate if more appropriate
[5] Categories A, B, C, and D, below, should sum to this total
[6] Specify; e.g., alternate mission equipment
[7] Identify by name, but not by individual cost
[8] Vendors/suppliers of raw materials and small item CFE
[9] Overhead, G&A, B&P, IR&D, fee/profit etc. Do not breakout.

NOTE: Liberal use of footnotes or attachments for explanations or clarifications is encouraged.

APPENDIX D

PROCEDURAL LESSONS LEARNED

APPENDIX D

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In addition to the substantive findings outlined in the body of this working paper, the study team learned (and re-learned!) some procedural lessons that may prove helpful to others who undertake similar kinds of studies.

- Allow time for unexpected delays. For example, key letters were lost (including the original copy of Admiral Hays' first tasking memorandum) or were misdirected. And, in fact, expect everything to be harder to accomplish than it seems and to take longer than one might think.

- Preparing for and following up on site visits are incredibly time consuming--but absolutely necessary. Giving contractors the maximum lead time creates good will and better responses. Thank-you letters mentioning particularly helpful individuals smooth the way for follow-up calls or visits.

- Work through the staff of the relevant Plant Representative's Office (PRO) until it suggests direct contacts with contractor staff.

- Allowing the PRO staff and the contractor to review the draft of trip reports builds confidence and helps ensure accuracy.

- Be candid, but respect confidences. Do everything necessary to protect competition-sensitive information.

- Air Force personnel were extremely cooperative. Where they have something to offer--insights, experience, data, a different viewpoint or modus operandi--make use of it. (Aircraft and missiles, of course, were natural subjects for this kind of cross-fertilization.) Be sure here, too, that particularly helpful individuals are formally recognized.

- In cases such as this one, in which the sponsor of the study is a senior Navy official, having a flag-rank point of contact and a task coordinator who is knowledgeable and supportive can greatly facilitate progress.

APPENDIX E

VCNO MEMORANDUM, 23 MAY 1986

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, DC 20350-2000

IN REPLY REFER TO
Ser 09/6U301045
23 May 1986

MEMORANDUM FOR THE PRESIDENT, CENTER OF NAVAL ANALYSES

Subj: ANALYSIS OF SUSTAINING ENGINEERING

1. On Tuesday, 29 April, CNA briefed me on the preliminary results of their sustaining engineering analysis. The original tasking requested CNA to address the following questions:

a. How much are we spending annually for sustaining engineering?

b. What are we buying?

c. What do we need?

d. What can we do to improve our management and control of sustaining engineering costs?

e. Is a more uniform contract cost reporting system feasible?

2. The briefing provided valuable insight and partial answers to these questions based on an examination of the F-14, F-15, F-16, F/A-18, and AWACS aircraft, and the HARM and C-4 missiles. Because of the potential benefits from better management and control of sustaining engineering, I would like CNA to continue the analysis by undertaking the following tasks:

a. Develop consistent and complete data on the original sample of aircraft and missiles in order to provide a detailed understanding of sustaining engineering.

b. Expand the sample of aircraft and missiles to include the A-6, E-2, AV-8B, P-3, Tomahawk, Harpoon, Phoenix, Sparrow, and Sidewinder.

c. In order to improve the management and control of sustaining engineering, attempt to establish relationships between amounts of sustaining engineering used, methods of management, and Measures of Effectiveness (MOEs) related to system reliability/maintainability/safety.

d. To the extent practicable, develop standards and methods for estimating future sustaining engineering requirements on an annual per unit basis.

e. In conjunction with subparagraphs a. through d. above, include a review of the control and funding of engineering change proposals with recommendations.

Subj: ANALYSIS OF SUSTAINING ENGINEERING

f. Additionally, if evidence warrants, suggest organizational arrangements that will enhance program managers' ability to negotiate and control sustaining engineering in production contracts.

g. Adapt and extend the study's methodology and scope to include surface ships, submarines, and ship-based weapon systems to include torpedoes and major electronics subsystems.

3. Please provide an analysis plan to accomplish these tasks at your earliest convenience. I would appreciate a progress report in September 1986, and a final briefing by December 1986. My point of contact for this project remains Rear Admiral J. D. Taylor, OP-921, 695-3262.

J. B. BUSEY
ADMIRAL, U. S. NAVY
VICE CHIEF OF NAVAL OPERATIONS

Copy to:
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END

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